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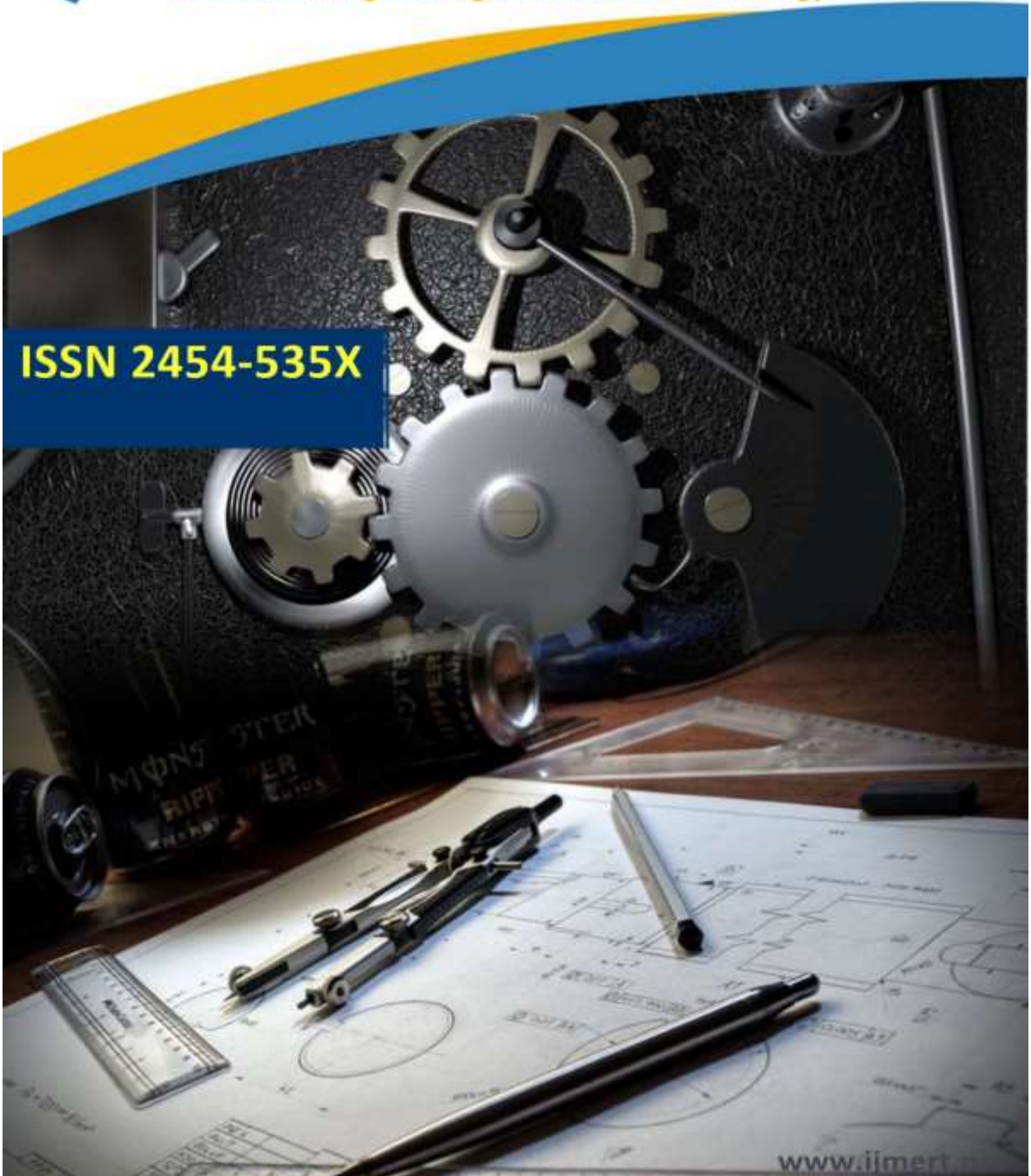

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PERFORMANCE AND ANALYSIS OF A CONDENSER WITH DIFFERENT REFRIGERANTS USING CFD

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Abstract

R-22 is a very commonly used refrigerant having wide applications. We have a big challenge to replace R-22 because of HCFCs, which deplete the ozone layer and harmful to the environment. As per Montreal Protocol we promised to be banned by 2020. Since being an unconventional &non eco-friendly product it is being replaced by R-134a. Nano Al2O3 gives better performance hence it is succeeded after R-22. Refrigerant R-134a is currently being used in every sector of industries, as a part of Nano element it was accepted having multipurpose use in less quantity. Being less in quantity & economical aspect considered it to be an influencing refrigerant till date. Having Al2O3 a metal component reduces its efficiency from being heated immediately, thus a new & more improved world-wide experimented refrigerant R-744 is introduced. Various eco-friendly & non ozone depleting refrigerant R-744 is manufactured by recycling the Co2 from atmosphere. It does not consist of any CFCs, hazardous chemicals and also available at cheap rate. Hence it is proving an efficient & sustainable refrigerant at current era. So, threw the present paper the highlighted study on compression refrigeration system is discussed.

Keywords: R-22, R-134a, R-744, Co2, CFCs, Al_2O_3

Introduction

Condensers in use today may fall in either of two categories: refrigerated or nonrefrigerated. Non- refrigerated condensers are widely used as raw material, product, and/or solvent recovery devices in chemical process industries. They are frequently used prior to control devices (e.g., incinerators or absorbers). Refrigerated condensers are used as air pollution control devices for treating emission streams with high VOC concentrations (usually > 5,000 ppmv) in applications involving gasoline bulk terminals, storage, etc. Condenser control technology is unique in that it not only reduces emissions to the atmosphere but also captures or recovers VOCs, potentially for additional use. Condensation is a separation technique in which one or more volatile components of a vapor mixture are separated from the remaining vapors through saturation followed by a phase change. The phase change from gas to liquid can be achieved in two ways: (a) the system pressure can be increased at a given temperature, or (b) the temperature may be lowered at a constant pressure. In a two-component system where one of the components is non condensable (e.g., air), condensation occurs at dew point (saturation) when the partial pressure of the volatile compound is equal to its vapor pressure. The more volatile a compound is (e.g., the lower the normal boiling point), the larger the amount that can remain as vapor at a given temperature; hence the lower the temperature required for saturation (condensation). Refrigeration is often employed to obtain the low temperatures required for acceptable removal efficiencies. This chapter is limited to the evaluation of refrigerated condensation at constant (atmospheric) pressure.

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The removal efficiency of a condenser is dependent on the emission stream characteristics including the nature of the VOC in question (vapor pressure/temperature relationship), VOC concentration, and the type of coolant used. Any component of any vapor mixture can be condensed

if brought to a low enough temperature and allowed to come to equilibrium. The vapor pressure dependence on temperature for selected compounds (Erikson, 1980). A condenser cannot lower the inlet concentration to levels below the saturation concentration at the coolant temperature. Removal efficiencies of approximately 50 to 90 percent can be achieved with coolants such as chilled water and brine solutions, and removal efficiencies above 90 percent can be achieved with ammonia, liquid nitrogen, chlorofluorocarbons, hydrochlorofluorocarbons, or hydrofluorocarbons, depending on the VOC composition and concentration level of the emission stream.

Objectives of the study

- The main objective is to replace R22 refrigerant which ones released reacts with the ozone layer, causing significant damage.
- And to analyze and identify better, efficient & sustainable replacement of R22 refrigerant among R134A and R 744.

Review of Literature

Dalkilic AS and Wongwises S[1] The study shows that HCR134a hydrocarbon refrigerant could be an alternative refrigerant for replacement the existing R134a refrigerant. Harby K[2] Results of the study showed that in spite of highly flammable characteristics, hydrocarbons can offer proper alternatives to the halogenated refrigerants from the standpoint of environment impact, energy efficiency, COP, refrigerant mass, and compressor temperatures. Pearson SF [3] concluded that R-134a have better performance than the R-22 also R-134a have zero ozone depletion potential and less global warming potential compare to R-22. The Metal particle of Al_2O_3 present in R-134a makes the Refrigerant efficient because of heated immediately. Another side R-744 which is made by recycling of CO_2 from atmosphere does not have any CFCs and also not hazardous to atmosphere also is very efficient refrigerant. R-744 has zero ODP, lowest GWP, non-toxic, and higher refrigerant performance than other refrigerants .Saleh B [4]The paper conclude that the BACKONE equations of state give generally a good accuracy for all thermodynamic data of refrigerants with the advantage of needing only few experimental data for the determination of its substance specific parameter.Yoon SH et al. [5] the paper that the heat transfer coefficients and pressure drop during the evaporation process of carbon dioxide in a horizontal tube have been investigated and At a low mass quality region during evaporation, heat transfer coefficient increases as mass quality increases because convective boiling becomes more dominant. But when mass quality is greater than a certain value, heat transfer coefficient tends to decrease.

It is because surface tension. Neksa P [6] The paper concluded that CO_2 is one of the natural substances and it is an environmentally benign, safe and economical refrigerant used for heating and cooling systems. Existing CO_2 HPWHs both in industrial and residential sectors have been reviewed in this study, i.e. low-temperature and high-temperature HPWHs (which are classified by the heat delivery temperature below and above 80 °C). The majority of the existing systems are still not able to deliver the water temperature above 100 °C due to the temperature gliding matching between water and sCO_2, the limitations in compressors, and the constraints in heat exchangers. Hesse U [7] Taking in consideration the current climate scenario many researchers has done to develop a refrigeration system that is both energy efficient and has less impact on environment. This environmental impact is directly and indirectly related to the use of HCFC and HFC refrigerants in refrigeration systems. The amount of depletion of Ozone layer is link to the use of HCF seeds and HFC refrigerant whose consequence is measured why the ODP index that is ozone depletion potential. And also shows the potential alternatives of the chlorofluorocarbons. Suneel K Kalla [8] The Paper shows that the performance of four refrigerants as possible alternatives to R-22 was studied with the help of cycled software. The values of COP were nearer to those of R-22, e.g. at 25, 45 and 55 °C condensing temperature, COP of R432a is lower than that of R22 by about 5.5%, 4% and 4.38% respectively. By resorting to hydrocarbon refrigerant as a substitute to R-22 we can reduce global warming and avoid ozone layer damage due to use of other refrigerants. However, the drawback of hydrocarbon refrigerants is their flammability due to which safety measures during their use is essential.

Research Methodology COMPUTATIONAL FLUID DYNAMICS

:

Computational Fluid Dynamics (CFD) is a branch of engineering and physics that involves the use of computer algorithms and numerical methods to simulate and analyse the behaviour of fluids (liquids and gases) and their interaction with physical objects. CFD can be used to model and predict fluid flow, heat transfer, chemical reactions, and other related phenomena in a wide range of applications such as aerodynamics, hydrodynamics, weather forecasting, combustion, and biomedical engineering.

CFD simulations involve breaking down a complex fluid flow problem into smaller, simpler components that can be analysed using mathematical equations and computational methods. These equations describe the behaviour of the fluid under various conditions, such as pressure, temperature, velocity, and viscosity. CFD software uses numerical methods to solve these equations and generate a detailed visual representation of the fluid flow behaviour, such as velocity vectors, pressure distribution, and temperature gradients.

CFD simulations can help engineers and scientists to optimize the design of fluid-based systems, such as pumps, turbines, heat exchangers, and air foils. By using CFD simulations to study the fluid dynamics of a system, engineers can identify potential design improvements, reduce energy consumption, and optimize performance. CFD is also widely used in research and development to gain a better understanding of complex fluid flow phenomena and develop new technologies.

Computational Fluid Dynamics (CFD) is a numerical analysis process used to simulate and analyse the behaviour of fluids and gases in motion. It involves the use of computational methods, algorithms, and computer software to solve and analyse complex fluid flow problems.

The CFD process typically involves the following steps:

1. Problem Definition: In this step, the problem is defined by specifying the physical boundaries and initial conditions of the fluid flow problem to be solved. This includes defining the geometryof the domain, the type of fluid, and the boundary conditions.
2. Grid Generation: In this step, a mesh or grid is generated over the geometry of the domain. The grid is used to discretize the fluid domain into a set of small cells or elements. The quality of the grid has a significant impact on the accuracy and efficiency of the CFD simulation.
3. Mathematical Modelling In this step, the governing equations of fluid dynamics, such as the Navier-Stokes equations, are discretized using numerical methods to obtain a set of algebraic equations that can be solved on a computer. The mathematical model also includes any additional physics, such as turbulence or heat transfer, that need to be considered in the simulation.
4. Solution Algorithm: In this step, a numerical solution algorithm is chosen to solve the discretized equations. This can include various numerical techniques such as finite volume, finite element, or spectral methods.
5. Simulation Execution: In this step, the CFD simulation is executed using the solution algorithm and the grid generated in the previous steps. The simulation results are then computed and stored for post-processing.
6. Post-Processing: In this step, the simulation results are analysed and visualized. This can include generating graphs and charts, creating animations of the fluid flow, and extracting information about key parameters such as pressure, velocity, and temperature.
7. Validation and Verification: In this step, the CFD results are compared with experimental or analytical data to validate and verify the accuracy of the simulation. This helps to ensure that the CFD results are reliable and can be used for engineering design and analysis.

The CFD process is iterative, and several iterations may be required to converge to a solution that is both accurate and stable. The CFD process is used in various fields, including aerospace, automotive, energy, and biomedical engineering.

Space claim:

Space Claim is a solid modeling CAD (computer-aided design) software that runs on Microsoft Windows and developed by Space Claim Corporation. The company is headquartered in Concord, Massachusetts. Space Claim Corporation was founded in 2005 to develop 3D solid modeling software for mechanical engineering. Its first CAD application was launched in 2007 and used an approach to solid modeling where design concepts are created by pulling, moving, filling, combining, and reusing 3D shapes. It was acquired by Ansys in May 2014, Inc, and was integrated in subsequent versions of Ansys Simulation packages as a built-in 3D modeler. Space Claim Corporation Markets Space Claim Engineer directly to end-user and indirectly by other channels. Space Claim also licenses its software for OEMs, such as ANSYS Flow International Corporation Catal CAD, and Ignite Technology which markets a version of Space Claim for jewelry design. The below figure shows the geometric modal of the condenser as shown in Figure 1.

The solution to a flow problem (velocity, pressure, temperature etc.) is defined at nodes inside each cell. The accuracy of a CFD solution is governed by the number of cells in the grid. In general, the larger the number of cells, the better the solution accuracy. Both the accuracy of a solution and its cost in terms of necessary computer hardware and calculation time are dependent on the fineness of the grid. Optimal meshes are often non-uniform: finer in areas where large variations occur from point to point and coarser in regions with relatively little change. Efforts are under way to develop CFD codes with a (self-) adaptive meshing capability. Ultimately such programs will automatically refine the grid in areas of rapid variations. At present it is still up to the skills of the CFD user to design a grid that is a suitable compromise between desired accuracy and solution cost. The below

Fig: 1 Geometry

Pre-processor

Pre-processing consists of the input of a flow problem to a CFD program by means of an operator- friendly interface and the subsequent transformation of this input into a form suitable for use by the solver. The user activities at the pre-processing stage involve:

- Definition of the geometry of the region of interest: the computational domain
- Grid generation – the sub-division of the domain into a number of smaller, non-overlappingsubdomains: a grid (or mesh) of cells (or control volumes or elements)
- Selection of the physical and chemical phenomena that need to be modelled.

figures [2-12] represents the Meshing of the Model and parameters considered.

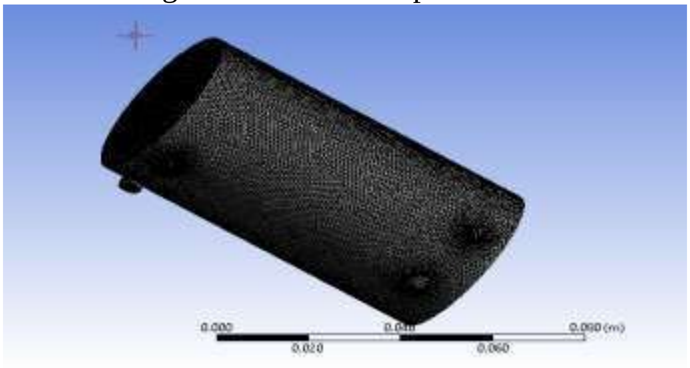


Fig:2 Mesh of the modal

Boundary conditions:

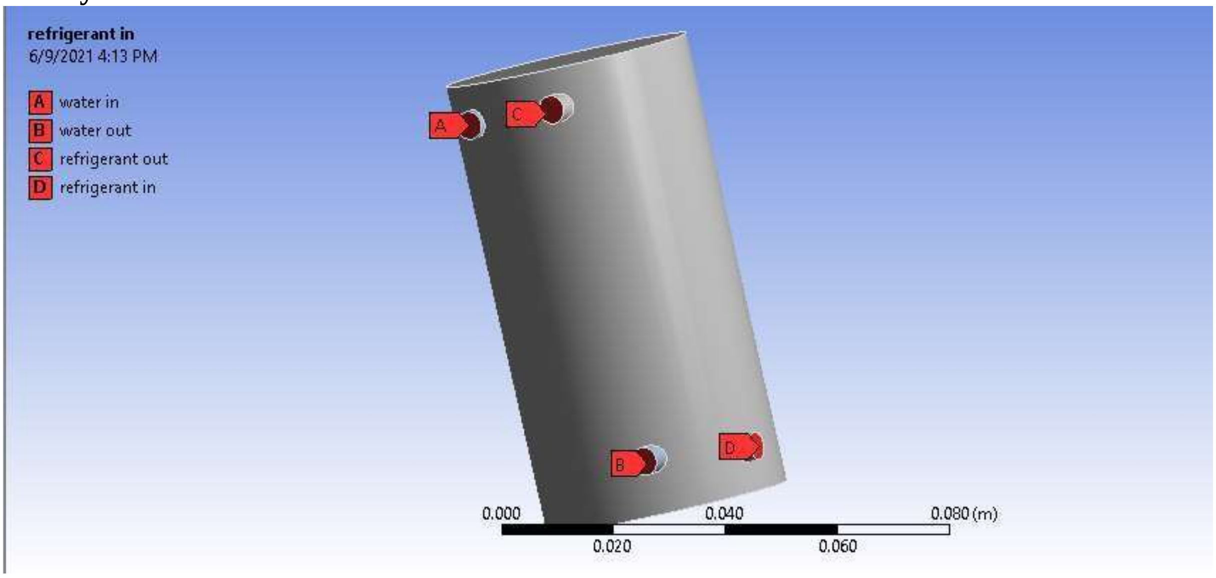


Fig:3 Boundary conditions of the model

RESULTS AND DISCUSSIONS:

R134a

A substantial amount of basic development work still needs to be done before these techniques are robust enough to be incorporated into commercial CFD codes and simulation is shown in Figures [4-12]

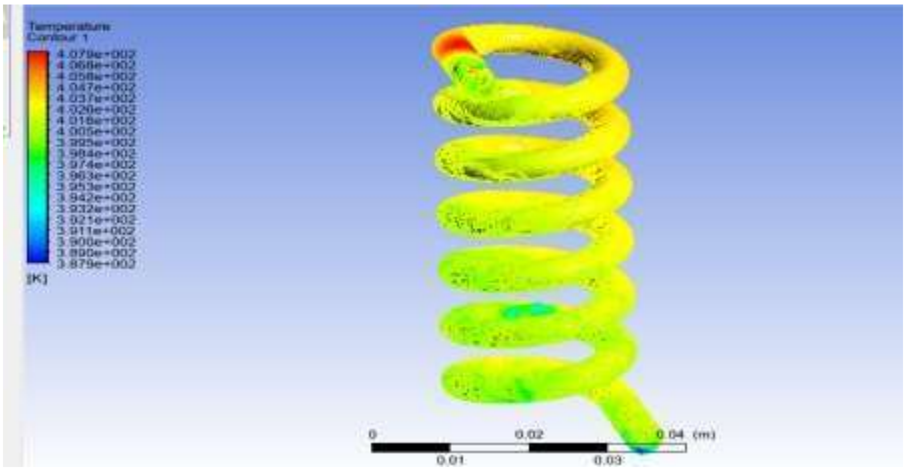


Fig:4 Temperature contour (R13a)

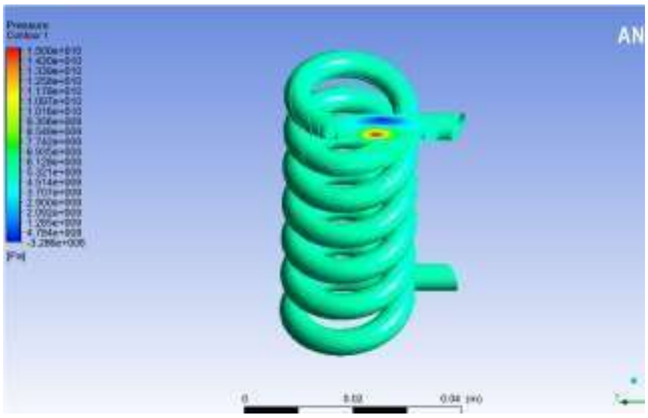


Fig:5 Pressure contour (R13a)

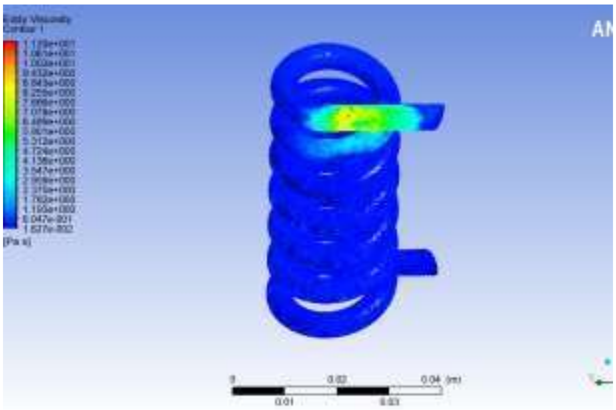


Fig:6 Eddy Viscosity(R13a)

Fig:7 Temperature contour (R22a)

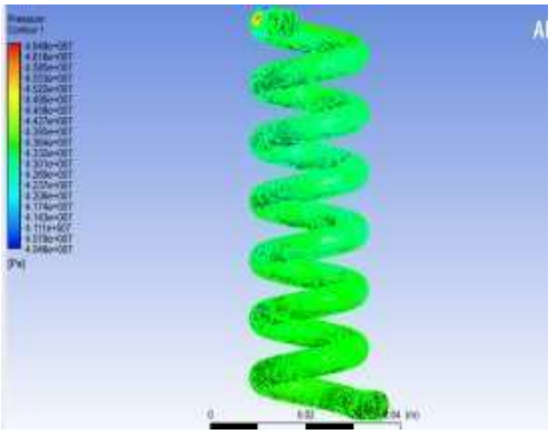
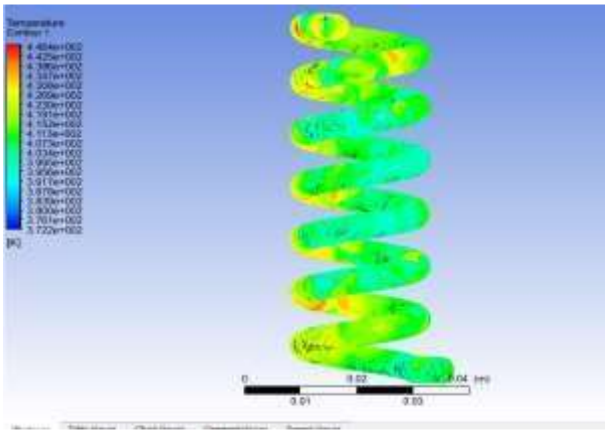


Fig:8Pressure contour (R22a)



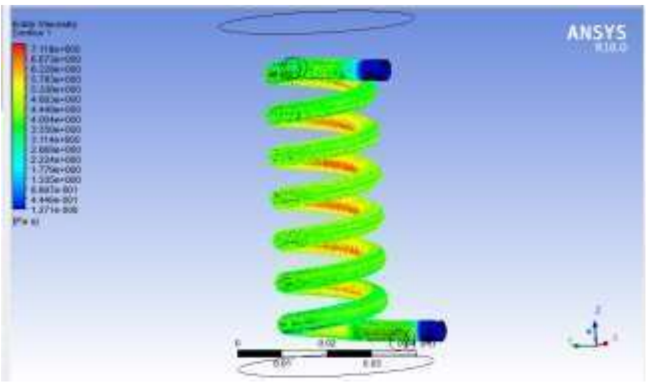


Fig:9Eddy Viscosity(R22a)

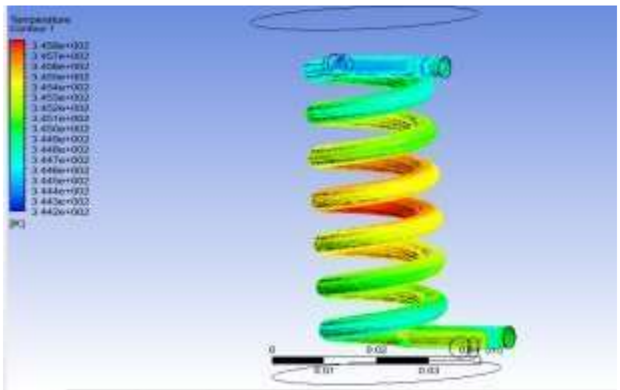


Fig:10 Temperature contour (R744)

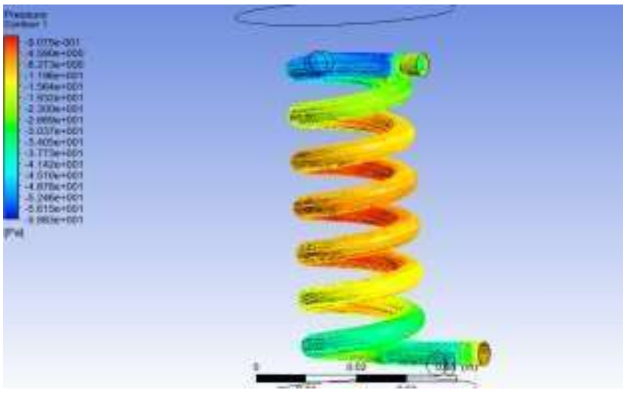


Fig:11 Pressure contour (R744)

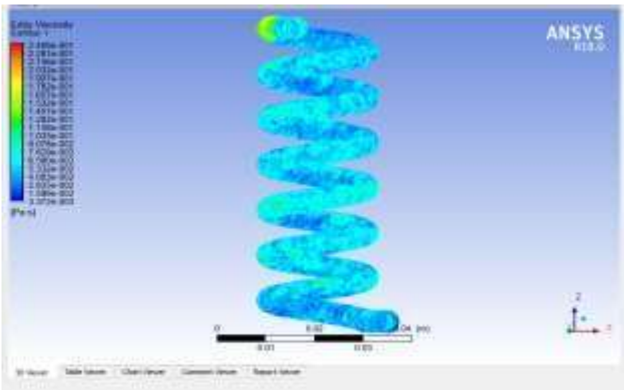
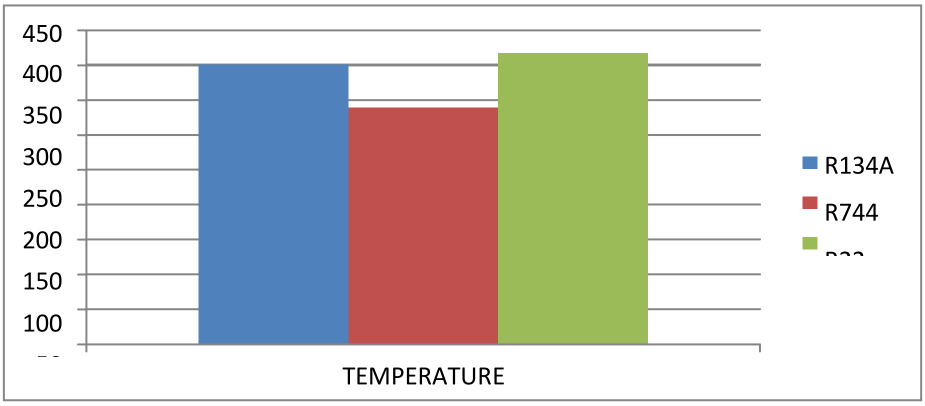


Fig:12 Eddy Viscosity(R744)

RESULTS: The Graph 1 shows the comparison of the temperatures of the three refrigerants, among those R744 liberates less temperature to the environment than other refrigerants.



Graph: 1 Comparing temperature variations

CONCLUSION:

It is concluded that by observing the temperature and pressure variations among these three refrigerants R-134a have better performance than the R-22 also R-134a have zero ozone depletion potential and less global warming potential compare to R-22. The Metal particle of Al2O3 present in R-134a makes the refrigerant inefficient because of heated immediately. On other side R-744 which is made by recycling of CO2 from atmosphere does not have any CFCs and also not hazardous to atmosphere also is very efficient refrigerant. R-744 has zero ODP, lowest GWP, non-toxic, and higher refrigerant performance than other refrigerants.

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